Decline of Yellow-Poplar Seed Trees Following Isolation

West Virginia University
Agricultural Experiment Station
Bulletin 565 June [illegible]

The Georgia Pacific—West Virginia University Experimental Forest

THE 3,000-acre Island Creek Experimental Forest was established in 1951 through a cooperative research agreement between the West Virginia University Board of Governors and the Island Creek Coal Company. In 1965 the surface ownership of this tract was acquired by the Georgia Pacific Corporation, and the name of this research forest was changed to the "Georgia Pacific — West Virginia University Experimental Forest." Since 1951 the timber management practices and research activities have been carried on under the supervision of the faculty of the West Virginia University Division of Forestry.

This research forest is located in Mingo County in the extreme southwestern part of West Virginia, the heart of the bituminous coal fields. These lands are presently considered of value primarily for their extensive coal deposits. The purposes in establishing this research forest were to demonstrate that Appalachian coal lands can also yield substantial returns as a continuous source of high-quality hardwoods, and to determine the best methods of forest production and utilization for the rugged terrain typical of this section of the State.

Topography divides the research forest into five natural units. These vary in size from 250 to 750 acres. Each unit, in turn, is subdivided into compartments of from 25 to 40 acres. Between 1953 and 1960 the mature timber on each compartment was harvested using seed-tree cuttings or shelterwood cuttings on one-half of the compartments and single-tree selection cuttings with 10- or 20-year cutting cycles on the remaining area. Since most of the compartments extend from bottom to ridge line, replicated areas exist which are ideal for comparing the effectiveness of these regeneration methods on the various slope positions and aspects, and studying the effects of these cuttings on the growth rate and quality of the residual trees.

West Virginia University Agricultural Experiment Station
College of Agriculture and Forestry
A. H. VanLandingham, Director, Morgantown

Decline of Yellow-poplar Seed Trees Following Isolation

KENNETH L. CARVELL*

Introduction

THERE HAS BEEN LITTLE use of the seed-tree method in hardwood forest types. Yellow-poplar (*Liriodendron tulipifera* L.), because of its ability to resist windthrow, nearly annual seed production, pattern of seed dispersal, and intolerance of shade, would appear to be one hardwood that is adapted to seed-tree cuttings.

However, for any regeneration method to be successful, it must not only result in a seedling crop of suitable density to permit its rapid development, but also take into account the effect of the cutting on the subsequent growth and condition of the residual stand. Unfortunately, most studies of seed-tree areas have been far more concerned with the abundance, distribution, and development of the new stand than with the future growth and condition of the seed trees.

Shortly after the first yellow-poplar seed-tree cuttings were made on the experimental forest, it was observed that the condition and vigor of these isolated stems were deteriorating. Initially epicormic branches developed on most stems. As these increased in abundance and size, dead and dying branches appeared in the crowns and some of the trees became stagheaded. Increment borings indicated that the rate of diameter growth had declined steadily since the time of release.

A detailed investigation was initiated during the summer of 1966 to discover how severe the decline in vigor had been during the period since the seed trees were isolated. The purpose of this study was to determine what the growth pattern had been since cutting, the extent of epicormic branching and crown deterioration, and the environmental conditions around isolated trees that were responsible for variations in condition and vigor.

*Kenneth L. Carvell is Silviculturist.

Review of Literature

Both in Europe and the United States seed-tree cuttings have been applied primarily in coniferous types. In the South seed-tree cuttings have been used successfully, at least under certain stand conditions, in the management of longleaf pine (*Pinus palustris* Mill.), loblolly pine (*Pinus taeda* L.), shortleaf pine (*Pinus echinata* Mill.), and slash pine (*Pinus elliottii* Engelm.) (Wahlenberg 1946, 1960, McCulley 1950, Dale 1958). Southern pine research has shown that a certain percentage of the seed trees are lost through lightning, windthrow, or insect attack (Pomeroy 1949, Trousdell 1955, Little and Mohr 1957). Thus, a normal mortality rate is anticipated in determining the proper number of seed trees to leave.

Exposed conifers are generally not subject to the same deterioration as hardwoods. Epicormic branching is not a problem with most pines, and crown deterioration and stagheadedness is uncommon if vigorous conifers are selected as seed trees. In the literature there appear to be few reports of serious growth decline following isolation of coniferous seed trees.

Studies of epicormic branching have generally been made on trees which were only partially exposed during cutting, i.e. following thinning, improvement cutting, patch cutting, or single-tree selection cutting. Following thinning in pole-sized yellow-poplar, Wahlenberg (1950) found that the number of epicormics increased with the degree of release and that most of these sprouts appeared on the open side of the bole. The most abundant epicormic branching was on lower-crown-class trees. Some genetic variation was evident between individual trees, with the light sprouters outnumbering the heavy sprouters three to one.

Smith (1965) reported that lower-crown-class yellow-poplar border trees around patch cuttings had more epicormics than dominants or codominants, and that epicormics were confined largely to the upper stem just below the crown. Since northern red oak (*Quercus rubra* L.) and black cherry (*Prunus serotina* Ehrh.) produced more epicormics than yellow-poplar, he concluded that yellow-poplar should be favored as border trees over northern red oak or black cherry.

In a Pennsylvania study the number of epicormics that developed on white oak and black oak (*Quercus velutina* Lam.) after thinning a 55-year-old stand was found to be more closely related to the number and distribution of pretreatment live branches than to the stocking level of the residual stand or vigor of sample trees (Ward 1966). Ward believed that tendency to initiate epicormics to be influenced to a considerable extent by genetics.

Clark and Boyce (1965) reported that yellow-poplar seed remained viable for at least four winters in the forest litter. Under natural conditions seed accumulated for several years and germinated when the seedbed conditions were suitable. They concluded that with proper cutting and favorable seedbed there is little reason to leave seed trees to reproduce yellow-poplar.

Description of Experimental Area

The land within the experimental forest consists of steep, V-shaped valleys. Most slopes have a 25 per cent grade, but occasionally grades as much as 50 per cent are encountered. Because of the difficulties inherent in logging slopes of this grade, the loggers of the virgin forests cut the stands clean and rolled or "ballhooted" the logs to the creek below, where they were skidded out over the stony creek bottoms. The virgin stands were logged between 1905 and 1915, leaving little except scattered culls. In 1953, when the first experimental cuttings were made, the second-growth stands were essentially evenaged and approximately forty years old.

From the time of initial logging until administration of this tract was assumed by the Division of Forestry, ground fires burned frequently in the fall and spring. These fires caused many of the trees to develop catface and butt rot. Since 1951 most of the research forest has been free from wildfire.

Yellow-poplar and cucumbertree (*Magnolia acuminata* L.) are the predominant commercial species on the lower- and middle-third slopes, and are abundant on the north-facing upper-third slopes. Associates of this cove type include northern red oak, white oak (*Quercus alba* L.), basswood (*Tilia americana* L.), white ash (*Fraxinus americana* L.), blackgum (*Nyssa sylvatica* Marsh.), sugar maple (*Acer saccharum* Marsh.), and red maple (*Acer rubrum* L.). Oak-hickory mixtures predominate on the dry sites, south-facing upper-third slopes and ridgetops. Here white oak and chestnut oak (*Quercus prinus* L.) are the characteristic cover, and blackgum a frequent associate. Scattered groups of conifers, pitch pine (*Pinus rigida* Mill.), or rarely shortleaf pine (*Pinus echinata* Mill.), crop out only where the soil is shallow. In general, pine is so restricted as to be of little significance in the management of this tract.

The productivity of the Forest is attested to by the size of the forty-year-old trees removed when the second-growth stands were cut. During this rotation some of the yellow-poplar had attained diameters of 20 inches, and cucumbertree and northern red oak, 16 inches. The tallest trees exceeded 110 feet in height.

Collection of Data

In the summer of 1966 sixty-eight yellow-poplar seed trees were selected from various slope positions on the seed-tree compartments. These trees showed various degrees of decline, and included those exposed on three or all faces during the seed-tree cutting. In addition, 21 yellow-poplar on uncut areas were selected for controls.

In studying each tree and the environmental conditions surrounding it, the following measurements or observations were made: present d.b.h., d.b.h. at time of cutting, total height, height to lowest live branch, and number of dead branches in crown. Evaluation of the environmental conditions around each seed tree included record of aspect, per cent slope, and slope position. The opening around each seed tree was mapped, showing the distance to the crown of the nearest tree of comparable size. The extent of logging damage to the bole and degree of soil disturbance around each seed tree were also recorded. Epicormic branching was rated as light, moderate, and heavy.

From increment cores the radial increments for the year of cutting and the nine years prior to cutting were obtained. In addition, the annual radial increment after cutting was measured. Since by 1966 some of the seed trees had been isolated for 12 years and some for only 6, the number of measurements for annual radial increment after cutting varied from one compartment to another.

Analysis of Data

DIAMETER GROWTH

Preliminary plotting of the diameter increment per year after cutting indicated that the decline in diameter growth after release was a straight line relationship. Thus, a regression equation was selected of the form:

$$Y = b_0 + b_1X$$

where

Y = the diameter increment in a specific year after the seed tree was isolated,

X = the number of years since the seed-tree cutting,

b_0, b_1 = numerical coefficients to be derived from the data.

Initially separate regressions were computed for seed trees on lower-, middle-, and upper-third slope positions. Statistical tests indicated that each of these regression coefficients was significant at the 1 per cent level. However, comparisons between the constants and regression coefficients of these three regressions indicated that the equation for each

slope position was not significantly different from the other two equations. Thus, the data for all three slope positions were pooled (see Table 1).

TABLE 1

Regression Equations Showing the Annual Diameter Growth (Y) for a Specific Year after Cutting (X) by Slope Position

Slope Position	Regression Equation
Lower-third	0.3509 - 0.02676 X
Middle-third	0.3617 - 0.02686 X
Upper-third	0.3860 - 0.02922 X
All slope positions combined	0.3632 - 0.02734 X

The 21 control trees showed no decline in diameter growth during the period, 1947-1966. The average annual diameter growth for the controls during this period was 0.3658 inch, a mean very similar to the constant of the equations presented in Table 1.

To discover whether all yellow-poplar, regardless of growth rate at time of release, responded similarly to isolation, the correlation between average annual diameter increment in the ten years prior to isolation (X) and annual diameter increment in the six years after isolation (Y) was investigated. This produced the significant equation:

$$Y = 0.1351 + 0.4741\ X$$

This relationship is shown in Figure 1.

Further analyses of growth response data were made to clarify these changes in vigor. Table 2 is a tabulation of these results.

EPICORMIC BRANCHING

Various tests were made between degree of epicormic branching and environmental factors. Of the 68 experimental trees, 30 had light

TABLE 2

Comparison of Average Annual Diameter Growth Before and After Cutting by Vigor Classes

Vigor Class	Number of Trees	Average Annual Diameter Growth Prior to Cutting	Average Annual Diameter Growth After Cutting	Per Cent Change
		inch	*inch*	
Low	6	0.11	0.14	27.[illegible]
Below average	25	0.22	0.22	0.0
Average	26	0.30	0.27	11.1
Above average	11	0.44	0.29	34.1

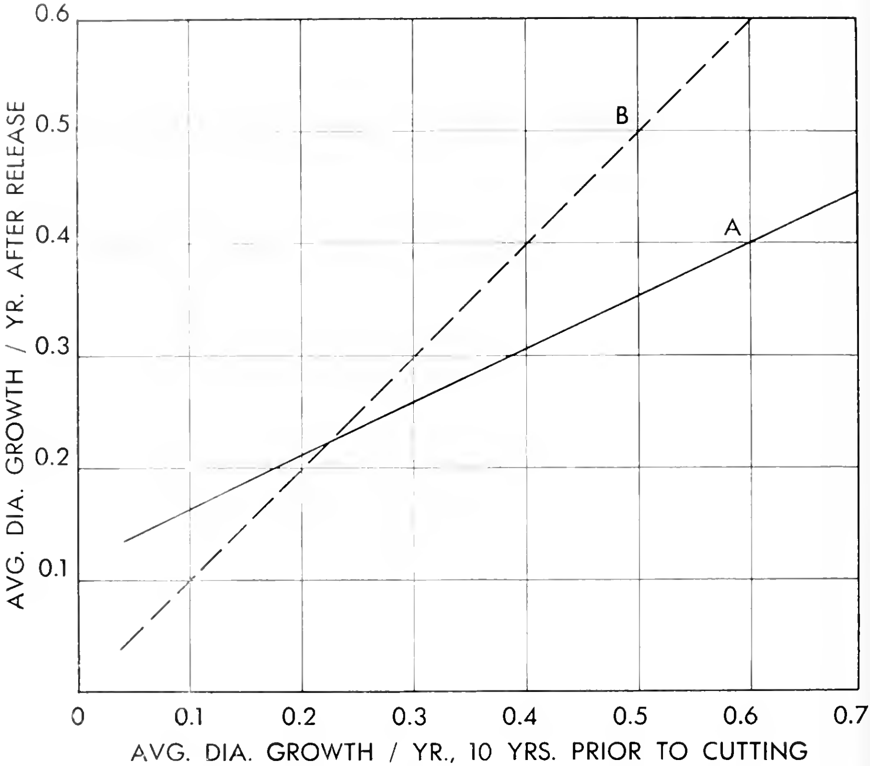

FIGURE 1. Regression line "A" indicates the relation between average annual diameter increment (inches) in the ten years prior to isolation and annual diameter increment in the years after isolation. The broken line "B" shows what might have been the anticipated increment, if the trees had not been isolated.

epicormic branching, 10 branches or less restricted to the area immediately below the main crown; 20 had average epicormic branching; and 18 had heavy epicormic branching, branches nearly to the base of the tree.

There was no correlation between the number of epicormics and degree of release, d.b.h. at time of cutting, crown length at time of release, slope position, or aspect.

DISTURBANCE

There was no apparent correlation between degree of disturbance during logging and the decline in diameter growth or the degree of epicormic branching.

Discussion

Seed-tree cuttings have been recommended for reproduction cove hardwood stands where a large component of yellow-poplar is desired in the next rotation. From this study and observation of yellow-poplar seed-tree cuttings in other sections of the State, it is apparent that these recommendations have not been based on empirical studies, but on speculation based on windfirmness, seed dispersal, and shade tolerance. With the great emphasis now placed on selecting only the best trees in each stand for seed, the decline in growth, vigor, and condition can mean a substantial loss of revenue.

When the problem of seed tree deterioration and the likelihood of adequate yellow-poplar seed present in the litter are weighed together, it appears that yellow-poplar seed trees are often an unnecessary luxury. When vigorous poplar exist in the older stand, an adequate amount of reserve seed may be present in the litter (Clark and Boyce 1965). Many seedlings arising after yellow-poplar seed-tree cuttings have probably come from seed already present in the litter prior to cutting.

At present there is need for a practical field method for sampling litter in cove hardwood types to determine

FIGURE 2. A pair of yellow-poplar seed trees, 12 years after isolation. The tree on the left has a moderate number of epicormic branches, and the tree on the right has heavy epicormics. Many branches in the original crown have died back, and the boundary between the old crown and the epicormics is indistinct.

whether enough viable poplar seed is present for an adequate seedling crop. Such a sampling technique would identify those stands where the shortage of seed dictates small clearcuttings so that seed from border trees can bolster the scant seed supply. It would also identify those stands which could be clearcut in large blocks with no consideration of additional seed source.

In this study the greatest loss in annual increment during the 10-year period after cutting occurred in those poplar which had the highest growth rates prior to release (Table 2). Since general recommendations for selecting seed trees stress leaving only those with high vigor and large crowns, it can be assumed that any seed tree chosen on this basis would suffer serious decline after release.

Ten years after cutting, high vigor yellow-poplar seed trees would be increasing in diameter at only 25 per cent of the rate before cutting (Table 1). The factors responsible for this decline may involve changes in soil temperature and soil moisture resulting from the increased sunlight reaching the forest floor. The pronounced increase in surface soil temperature would result in increased water loss from these layers through evaporation.

After cutting a great invasion of herbs and woody vegetation occurs on these moist sites. Studies in Missouri

FIGURE 3. A yellow-poplar seed tree, 12 years after the regeneration cutting. This tree has developed heavy epicormic branching. The crown has gradually deteriorated, and the tree is now dying back at the top.

(Rogers and Brinkman 1965) showed that the removal of all hardwoods in the understory of a stortleaf pine stand increased volume growth of unthinned stands about 40 per cent in ten years. Thus, understory vegetation competes heavily with older trees for moisture. Following yellow-poplar seed-tree cuttings, as the vegetation on the forest floor becomes denser and taller, soil temperature would gradually approach that under the original stand, but competition for moisture between the new root systems and the older root systems of the seed trees would become an increasingly critical factor. It is possible that this increasing competition for moisture after seed-tree cutting is a primary cause of the change in physiological balance, resulting in epicormic branching and progressive decline in diameter growth.

Summary

Six to 12 years after reproduction cuttings in cove hardwood stands in southern West Virginia, the diameter growth and degree of epicormic branching of yellow-poplar seed trees was studied. Analysis of these data indicated that there had been a progressive decline in diameter growth after cutting. Ten years after isolation, the diameter growth of seed trees was only 25 per cent of their rate prior to cutting. The greatest decline in growth occurred among those trees which had the greatest diameter growth prior to cutting.

All of the seed trees developed epicormic branching. Thirty had light epicormic development, 10 branches or less right below the main crown; 20 had a moderate amount of epicormic branching; and 18 showed heavy epicormic branching, epicormics nearly to the base of the tree. There was no correlation between the extent of epicormic branching and crown length at time of release, slope position, or aspect.

When the prospect of seed tree deterioration and the likelihood of adequate yellow-poplar seed already present in the litter are weighed, it appears that on many cover sites the use of yellow-poplar seed trees is an unnecessary and expensive practice.

Literature Cited

Clark, F. B. and S. G. Boyce. 1965. Yellow-poplar seed remains viable in the forest litter. J. Forestry 63: 564-567.

Dale, M. E. 1958. Ground treatment and seed supply influence establishment of shortleaf pine reproduction. Central States For. Expt. Sta. Note 119. 2 pp.

Little, S. and J. J. Mohr. 1957. Growth and mortality of residual loblolly pines after a seed-tree cutting. Northeast. For. Expt. Sta. Res. Note 75. 4 pp.

McCulley, R. D. 1950. Management of natural slash pine stands in the flatwoods of south Georgia and north Florida. U.S.D.A. Circ. 845. 57 pp.

Pomeroy, K. B. 1949. Loblolly pine seed trees: selection, fruitfulness, and mortality. Southeast. For. Expt. Sta. Paper 5. 17 pp.

Rogers, N. F. and K. A. Brinkman. 1965. Shortleaf pine in Missouri. Understory hardwoods retard growth. U. S. For. Serv. Res. Paper CS-15. 9 pp.

Smith, H. C. 1965. Effects of clearcut openings on quality of hardwood border trees. J. Forestry 63: 933-937.

Trousdell, K. B. 1955. Loblolly pine seed tree mortality. Southeast. For. Expt. Sta. Paper 61. 11 pp.

Wahlenberg, W. G. 1946. Longleaf pine. Its use, ecology, regeneration, protection, growth and management. Charles L. Pack Forestry Foundation, Washington. 429 pp.

Wahlenberg, W. G. 1950. Epicormic branching of young yellow-poplar. J. Forestry 48: 417-419.

Wahlenberg, W. G. 1960. Loblolly pine, its use, ecology, regeneration, protection, growth and management. Duke University School of Forestry, Durham, N. C. 603 pp.

Ward, W. W. 1966. Epicormic branching of black and white oaks. For. Sci. 12: 290-296.